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SYNOPSIS

ON

"Synthesis of Silver and Gold nanoparticles from Latex containing plants, their characterization and antimicrobial applications".

(For the Award of Ph.D. Degree in the Faculty of Science)

[Botany]

Submitted to:

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Introduction:

Nanotechnology is a field of science, engineering, and technology that deals with the creation and use of materials at the nanoscale, i.e., 1–100 nm. It could provide new properties to any material by converting the bulk materials into nanosized materials, and these materials might be solutions to several problems related to human society. Nanomaterials play a crucial role in fields like biotechnology, biomedical, environmental, energy, and engineering due to their unique properties, including their large surface area, high electrical conductivity, and enhanced thermal and optical features. Nanoparticles can be produced through physical, chemical, photochemical, and biological methods, each with its own set of advantages and disadvantages. The main challenge in nanomaterial research is centered around designing and developing multifunctional nanoparticles (Pandian et al., 2021). Gold and silver nanoparticles were extensively used as theragnostic agents for the diagnosis and treatment of various diseases such as cancer, bacterial, Alzheimer's, Parkinson's, and viral therapies (Saxena et al. 2012; Lu et al. 2008). Plants have a long history of providing bioactive compounds. Since the last few decades, extensive research has been carried out on nanomaterial fabrication using plants and their different parts. Silver and gold nanoparticles may be fabricated by several methods, such as physical, chemical, and biological ones. The synthesis of nanoparticles with various toxic chemicals may lead to the capping of toxic chemical species on the nanoparticle surface, affecting adverse biological applications (Jha et al. 2009). Rahuman et al. (2022) reviewed the use of medicinal plants for synthesizing metallic nanoparticles in biomedical applications.

A comparative study of the antimicrobial activity of silver, gold, and silver/gold bimetallic nanoparticles synthesized through green synthesis approaches was conducted in several studies. The studies utilised plant extracts like *Hippeastrum hybridum*, *Gmelina arborea*, *Salix alba* L., etc. to fabricate nanoparticles (Khalil et al., 2018; Sher et al., 2022; Sandulovici et al., 2022). Silver nanoparticles (AgNPs) exhibit exceptional antimicrobial effects even at low concentrations

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and are commonly utilized for their antimicrobial and antitumor effects, as well as for promoting wound healing and reducing wound inflammation. The green synthesized plant-based nanoparticles exhibit environmentally friendly traits, excellent yield, and stability with a distinct morphology. They also offer significant benefits in industrial applications, such as cost-effectiveness and scalability, unlike chemically or physically synthesized NPs, which can be costly and have environmental consequences (Fatima et al., 2021).

Over the past decade, it has been demonstrated that biological systems, including plants and algae, can convert inorganic metal ions into metal nanoparticles (NPs) by utilizing the reductive and capping properties of biomolecules and metabolites present in these organisms. These findings highlight the potential of green-synthesized silver, gold, and silver/gold bimetallic nanoparticles as effective antimicrobial agents, offering a promising alternative to conventional antimicrobial therapies.

Review of literature:

The use of nanotechnology existed in ancient times, as can be proved by several usages and literatures available that demonstrated the use of fine materials by humans in the form of Ayurvedic Bhasma (Brown et al., 2007). Nagarjuna, in the 8th century AD, reported the use of silver and gold as medicinal agents for the first time in India. He used a combination of metals and herbs (Rai et al., 2008).

Lepidium sativum L. synthesized silver nanoparticles demonstrated potent antimicrobial activity against 10 reference pathogenic strains, suggesting their potential applications as a microbicide, disinfectant, and wound care solution (Bloukh et al., 2021). According to Manosalva et al. (2019), the biosynthesis of silver nanoparticles using *Galega officinalis* extract and synthesized nanoparticles at optimum conditions resulted in antimicrobial activity against *Escherichia coli, Staphylococcus aureus, and Pseudomonas syringae*. Salayová and colleagues employed five plant extracts: *Berberis vulgaris, Brassica nigra, Capsella bursa-pastoris, Lavandula angustifolia, and*

Origanum vulgare, for the synthesis of environmentally friendly silver nanoparticles (AgNPs). They also analysed the size and shape of the AgNPs, as well as their antioxidant and phenolic content (Salayová et al., 2021). Another study utilised *Annona muricata* leaf extract to biosynthesize gold nanoparticles, which exhibited significant antibacterial and antifungal activities against pathogenic strains (Folorunso et al., 2019). AuNPs synthesized from various plant extracts have exhibited promising antibacterial properties against *Pseudomonas aeruginosa*. Notably, studies utilising *Tinospora cordifolia and Hemidesmus indicus* L. as reducing agents have demonstrated significant antibiofilm activity against multidrug-resistant strains of *P. aeruginosa.* These gold nanoparticles have effectively reduced biofilm formation, the motility of *P. aeruginosa,* and exopolysaccharide production.

Furthermore, the synthesized AuNPs demonstrated varying levels of antibacterial effects against both *P. aeruginosa and Staphylococcus aureus*, as well as cytotoxic effects on cancer cell lines (S. A. Ali et al., 2022; Rajkumari et al., 2017; Parveen et al., 2021; S. A. Ali et al., 2020; Sakthivel et al., 2022). The eco-friendly synthesis of AuNPs and AgNPs introduces a novel strategy for tackling antimicrobial resistance issues, highlighting the potential of green synthesized metal nanoparticles.

Objectives:

The present study has been designed with the subsequent aims and objectives:

- Optimization of the green synthesis process (duration of sunlight exposure, inoculum dose, and concentration of metal ions) for silver and gold nanoparticles from selected plants.
- Characterization of the green synthesized silver and gold nanoparticles.
- Screening of the antimicrobial activity (antibacterial and antifungal) of the silver and gold nanoparticles.

Methodology and Plan of Work:

- Selection of suitable plants rich in phytochemicals such as phenolics, flavonoids, alkaloids, etc., and preparation of aqueous extract.
- Synthesis of silver and gold nanoparticles following the procedure of Singh. et al., 2017; Singh. et al., 2019.
- The process of synthesizing nanoparticles, like sunlight exposure time, inoculum dose, and metal ion concentrations, will be optimized. The synthesis will be regularly monitored using UV-visible spectroscopy.
- The optimally synthesized nanoparticles will be characterized using transmission electron microscopy (TEM), X-ray diffractometers (XRD), and Fourier transform infrared spectroscopy (FTIR).
- Determination of phenolics and flavonoid content of the plant extract using a modified Folin and Ciocalteu method and an aluminium chloride colorimetric assay, respectively. Tests for tannins will be performed by adding 1-2 drops of $FeCl_3$ to 2 ml of plant extract. Plant extract will be positive for tannins if it forms a blue, black, or brown precipitate.
- The optimally synthesized nanoparticles will be screened for antimicrobial activity on pathogenic bacterial and fungal strains using the disk diffusion method.

References:

1. Muthu Kumara Pandian, A., Gopalakrishnan, B., Rajasimman, M., Rajamohan, N., &Karthikeyan, C. (2021). Green synthesis of bio-functionalized nano-particles for the application of copper removal - characterization and modeling studies. *Environmental research*, *197*, 111140.
2. Saxena A, Tripathi R, Zafar F, Singh P (2012). Green synthesis of silver nanoparticles using aqueous solution of *Ficus benghalensis* leaf extract and characterization of their antibacterial activity, Mater Lett 67(1); 91-94.
3. Lu L, Sun R, Chen R, Hui CK, Ho CM, Luk JM, Lau G, Che CM (2008). Silver nanoparticles inhibit hepatitis B virus replication, Antivir ther 13(2); 253.
4. Jha AK, Prasad K, Prasad K, Kulkarni AR (2009). Plant system: nature's nanofactory, Colloids Surf B Biointerfaces 73; 219-23.

5. Rahuman, H. B. H., Dhandapani, R., Narayanan, S., Velmurugan, P., Paramasivam, R., Ramalakshmi, S., Thangavelu, S., & Saravanan, M. (2022). Medicinal plants mediated the green synthesis of silver nanoparticles and their biomedical applications. IET Nanobiotechnology (Print), 16(4), 115–144.
6. Sher, N., Alkhalifah, D. H. M., Ahmed, M., Mushtaq, N., Shah, F. U., Fozia, F., Khan, R. A., Hozzein, W. N., & Aboul-Soud, M. a. M. (2022). Comparative study of antimicrobial activity of Silver, Gold, and Silver/Gold bimetallic nanoparticles synthesized by Green Approach. Molecules (Basel. Online), 27(22), 7895.
7. Khalil, M., Sabry, D. Y., & Mahdi, H. (2018). Green synthesis of silver, gold and silver-gold nanoparticles: Characterization, antimicrobial activity and cytotoxicity. Journal of Scientific Research in Science, 34(part1), 553–574.
8. Sandulovici, R., Mihailescu, C., Grigoroiu, A., Moldovan, C., Savin, M., Ordeanu, V., Voicu, S. N., Cord, D., Costache, G. M., Gălăţanu, M. L., Popescu, M., Sarbu, I., Mati, E., Ionescu, L., Neagu, R., Ţucureanu, V., Claudia, R. M., Mihalache, I., Romaniţan, C., . . . Dragomir, D. (2022). The Physicochemical and Antimicrobial Properties of Silver/Gold Nanoparticles Obtained by "Green Synthesis" from Willow Bark and Their Formulations as Potential Innovative Pharmaceutical Substances. Pharmaceuticals (Basel), 16(1), 48.
9. Fatima, F., Aldawsari, M. F., Ahmed, M. M., Anwer, M. K., Naz, M., Ansari, M. J., Hamad, A. M., Zafar, A., & Jafar, M. (2021). Green synthesized silver nanoparticles using *Tridax procumbens* for topical application: excision wound model and histopathological studies. Pharmaceutics (Basel), 13(11), 1754.
10. Brown CL, Bushell G, Whitehouse MW, Agrawal DS, Tupe SG, Paknikar KM, Tiekink ERT (2007). Nanogold-pharmaceutics (i) The use of colloidal gold to treat experimentally-induced arthritis in rat models;(ii) Characterization of the gold in Swarna bhasma, a microparticulate used in traditional Indian medicine, Gold Bull 40; 245-250.
11. Rai RK, Jha CB, Chansuriya JPN, Kohli KR (2008). Comparative assessment of antihyperlipidaemic action of Tamra Bhasma, Indian J Tradit Know 7(2); 335- 340.
12. Haj Bloukh, S., Edis, Z., Abu Sara, H., &Alhamaidah, M. A. (2021). Antimicrobial Properties of *Lepidiumsativum L.* Facilitated Silver Nanoparticles. Pharmaceutics, 13(9), 1352.
13. Manosalva, N., Tortella, G., Cristina Diez, M., Schalchli, H., Seabra, A. B., Durán, N., &Rubilar, O. (2019). Green synthesis of silver nanoparticles: effect of synthesis reaction parameters on antimicrobial activity. World journal of microbiology & biotechnology, 35(6), 88.
14. Salayová, A., Bedlovičová, Z., Daneu, N., Baláž, M., LukáčováBujňáková, Z., Balážová, Ľ., &Tkáčiková, Ľ. (2021). Green Synthesis of Silver Nanoparticles with Antibacterial Activity Using Various Medicinal Plant Extracts: Morphology and Antibacterial Efficacy. Nanomaterials (Basel, Switzerland), 11(4), 1005.
15. Folorunso, A. S., Akintelu, S. A., Oyebamiji, A. K., Ajayi, S. O., Abiola, B. E., Abdusalam, I., & Morakinyo, A. (2019). Biosynthesis, characterization and antimicrobial activity of gold nanoparticles from leaf extracts of *Annona muricata*. Journal of Nanostructure in Chemistry, 9(2), 111–117.
16. Ali, S. A., Jalal, M., Ahmad, H., Umar, K., Ahmad, A., Alshammari, M. B., & Khan, H. M. (2022). Biosynthesis of Gold Nanoparticles and Its Effect against *Pseudomonas aeruginosa*. Molecules (Basel. Online), 27(24), 8685.

17. Rajkumari, J., Meena, H., Muralitharan, G., & Siddhardha, B. (2017). Green synthesis of anisotropic gold nanoparticles using hordenine and their antibiofilm efficacy against *Pseudomonas aeruginosa*. IET Nanobiotechnology (Print), 11(8), 987–994.
18. Parveen, A., Mahdi, H. S., & Azam, A. (2021). Antibacterial and anticancer activity of biologically synthesized gold nanoparticles. In Springer eBooks (pp. 163–184).
19. Ali, S. A., Ansari, M. A., Alzohairy, M. A., Alomary, M. N., Alyahya, S. A., Jalal, M., Khan, H. M., Asiri, S., Ahmad, W., Mahdi, A. A., El-Sherbeeny, A. M., & Awwad, E. M. (2020). Biogenic Gold Nanoparticles as Potent Antibacterial and Antibiofilm Nano-Antibiotics against *Pseudomonas aeruginosa*. Antibiotics (Basel), 9(3), 100.
20. Sakthivel, N., Vadivel, M., & Sakthivel, N. (2022). Bioinspired synthesis of gold nanoparticles from *Hemidesmus indicus* L. root extract and their antibiofilm efficacy against Pseudomonas aeruginosa. Process Biochemistry (1991), 122, 224–237.
21. Singh, A., Tiwari, R., Kumar, V., Singh, P., Khadim, S. R., Tiwari, A., Srivastava, V., Hasan, S. H., & Asthana, R. K. (2017). Photo-induced biosynthesis of silver nanoparticles from aqueous extract of *Dunaliella salina* and their anticancer potential. Journal of Photochemistry and Photobiology. B, Biology (Print), 166, 202–211.
22. Singh, A., Tiwari, R., Singh, V. K., Singh, P., Khadim, S. R., Singh, U., Laxmi, L., Srivastava, V., Hasan, S. H., & Asthana, R. K. (2019). Green synthesis of gold nanoparticles from *Dunaliella salina*, its characterization and in vitro anticancer activity on breast cancer cell line. Journal of Drug Delivery Science and Technology, 51, 164–176.